



Joseph Kolly, Ph.D.
Office of Research & Engineering

National Transportation Safety Board
Investigation Into Trans World Airlines Flight 800



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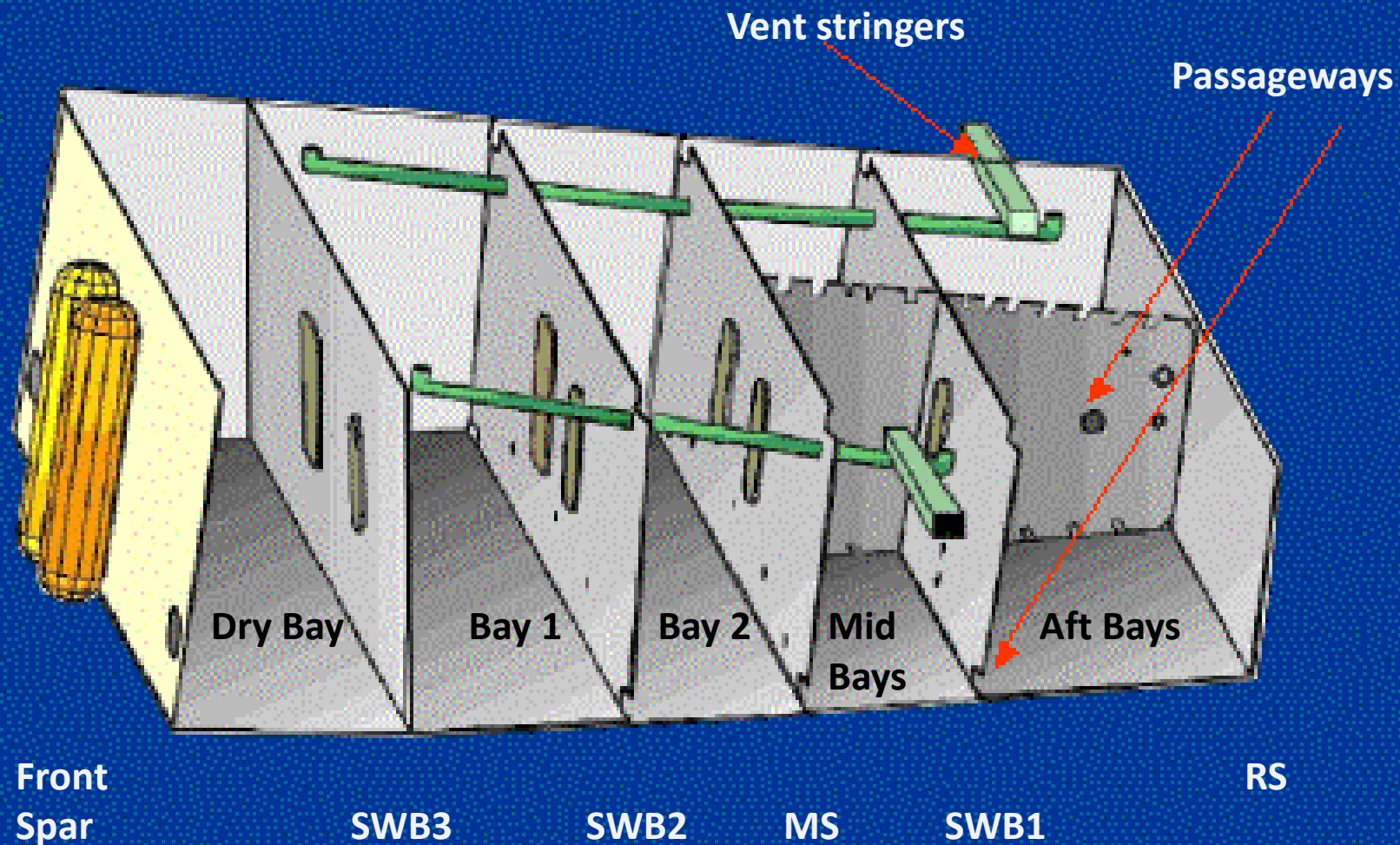
Key Findings

- The condition inside the center wing tank of TWA 800 was flammable
- The ignition and combustion of Jet A fuel can generate sufficient pressures to break apart the center wing tank



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747-100 Center Wing Tank



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**Flight Testing
JFK International Airport
July 1997**



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Duplication of

Boeing 747-100 aircraft

Weight and balance

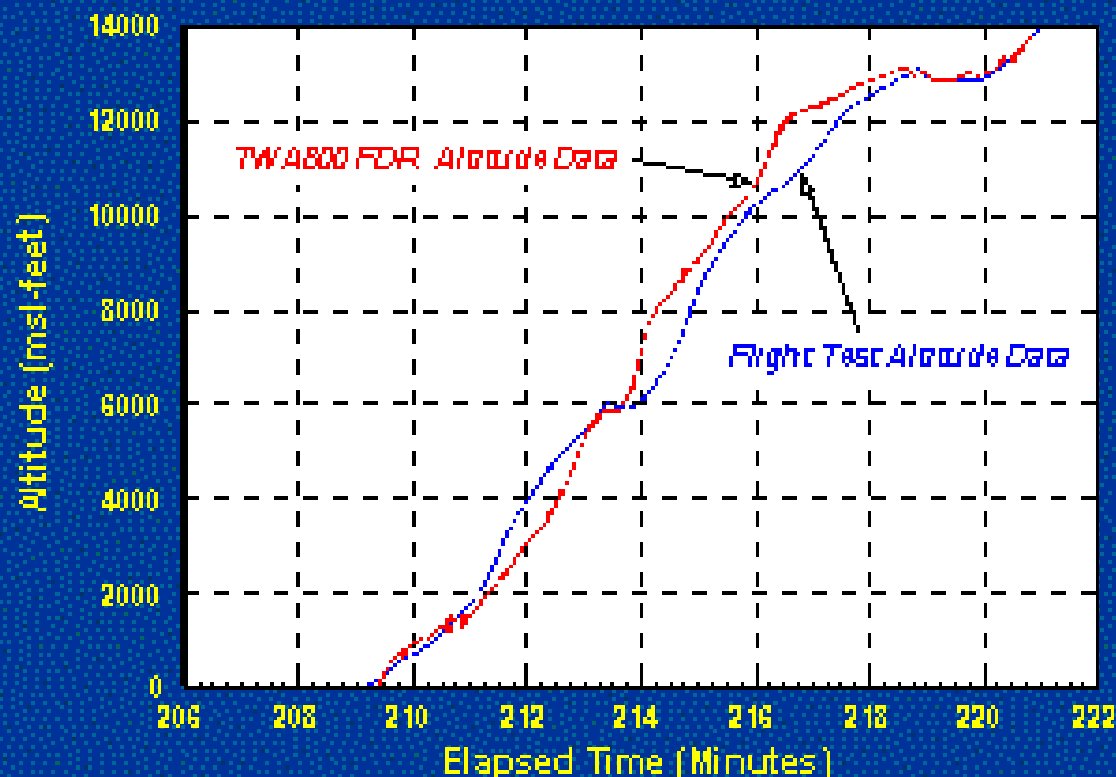
Fuel loading

Operations at same time of day

Similar climate

ECS pack operations

Followed TWA 800 ascent profile
as closely as possible

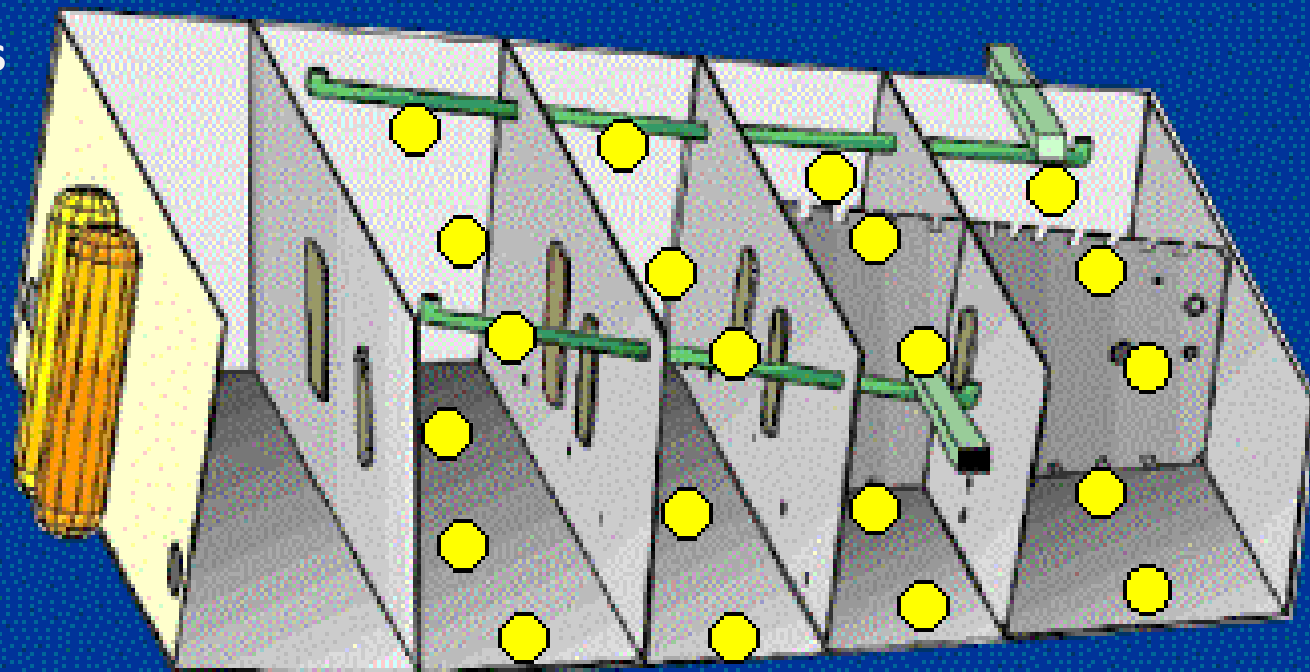




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- temperature sensors
- pressure sensors
- vibration sensors
- vapor sampling



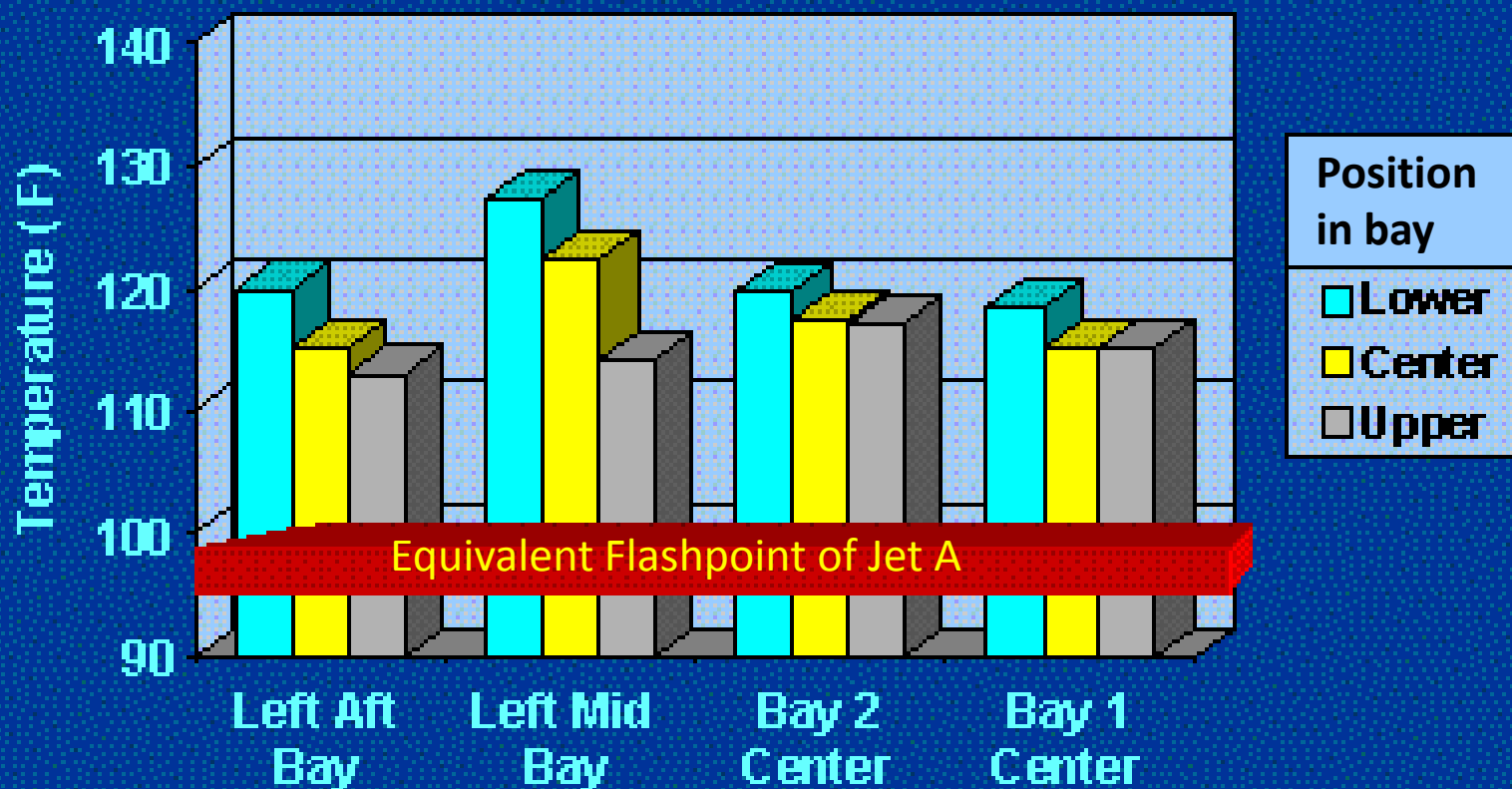
Positions shown for illustrative purposes, not actual layout

Flight Test Instrumentation



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TWA 800 Emulation Flight
Center Wing Tank Ullage Temperatures at 13,800 feet



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Fuel Vapor Sampling

**Desert Research
Institute**

- first in-flight samples
- confirmed flammability of TWA 800



Determine the Chemistry and Concentration
of the Fuel Vapor in the Center Wing Tank



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1997 to 2000

**University of
Nevada, Reno**

Fuel Chemistry Research

- included factors relevant to TWA 800
- enabled prediction of fuel flammability for all flight conditions
- confirmed flammability of TWA 800

Fundamental Research of Jet A Chemistry



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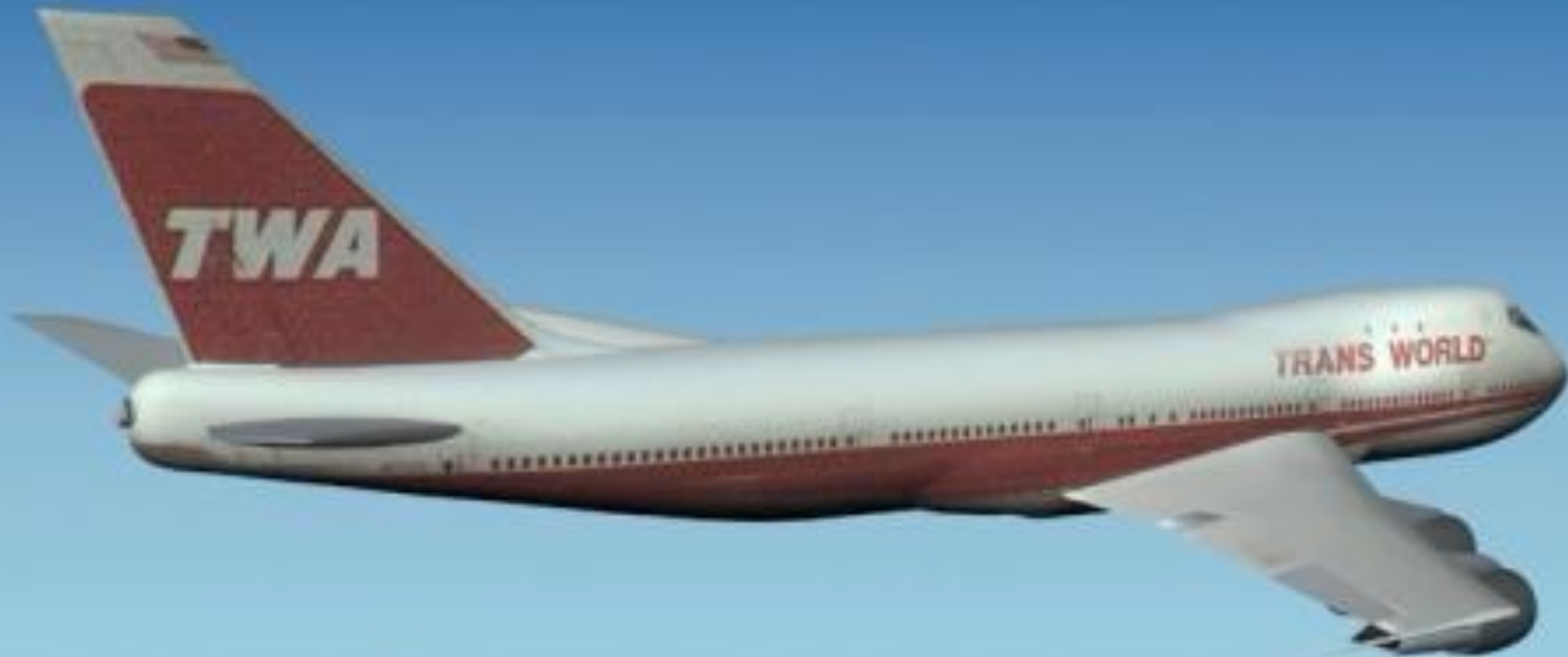
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Finding

- Three independent analyses showed that the conditions inside TWA 800's center wing tank were flammable

TWA

TRANS WORLD





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Findings

- Flight tests indicate that the center wing tank can be heated to temperatures much higher than ambient (external) temperatures
- The major source of this heat is the air conditioning system packs



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1996 to 2000

**California Institute
of Technology**

Ignition Energy and Combustion Research

Investigate the effect of factors
significant to TWA 800

- fuel type
- temperature range
- altitude
- fuel load

Fundamental Research of Jet A Combustion



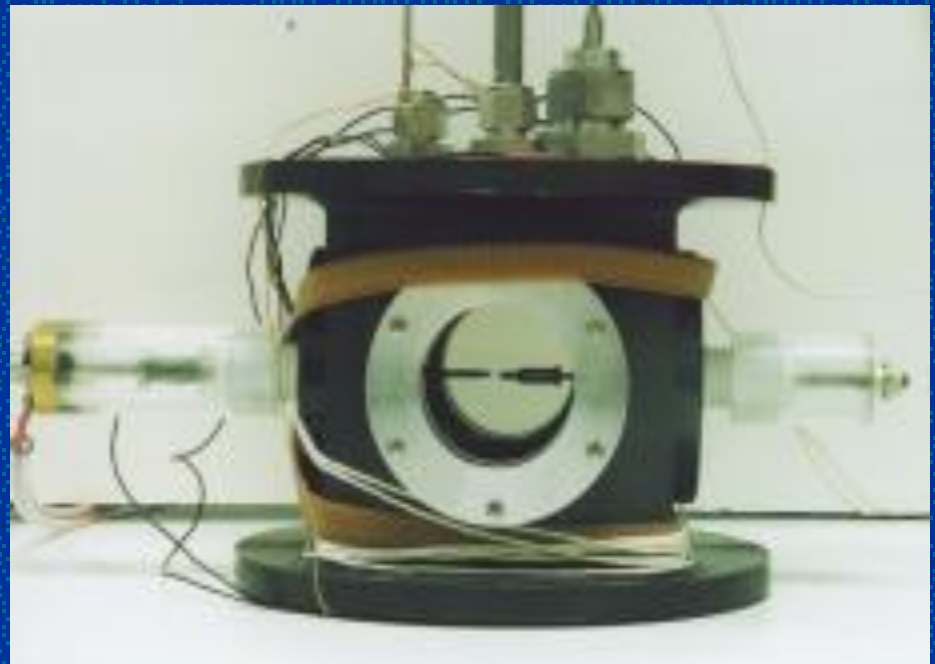
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Ignition Energy Research

Results of Research

- Energy required for ignition is between 0.5 and 500 millijoules



Test Chamber

Determine Energy Required for Jet A Ignition



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Combustion Research

Results of Research

- Peak combustion pressures between 39 and 52 psi
- Peak pressures exceed strength of CWT (25 psi)



Large Test Chamber

Determine Combustion Behavior of Jet A



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Findings

For the conditions on board TWA 800
at the time of the accident:

- Conditions inside center wing tank were flammable
- Ignition energy is between 0.5 and 500 millijoules
- Peak explosion pressures exceed failure pressures of center wing tank



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1/4-scale CWT Experiments, 1997 to 1999

**California
Institute of
Technology**

Phase 1

- Simulant fuel

**Applied
Research
Associates**

Phases 2 and 3

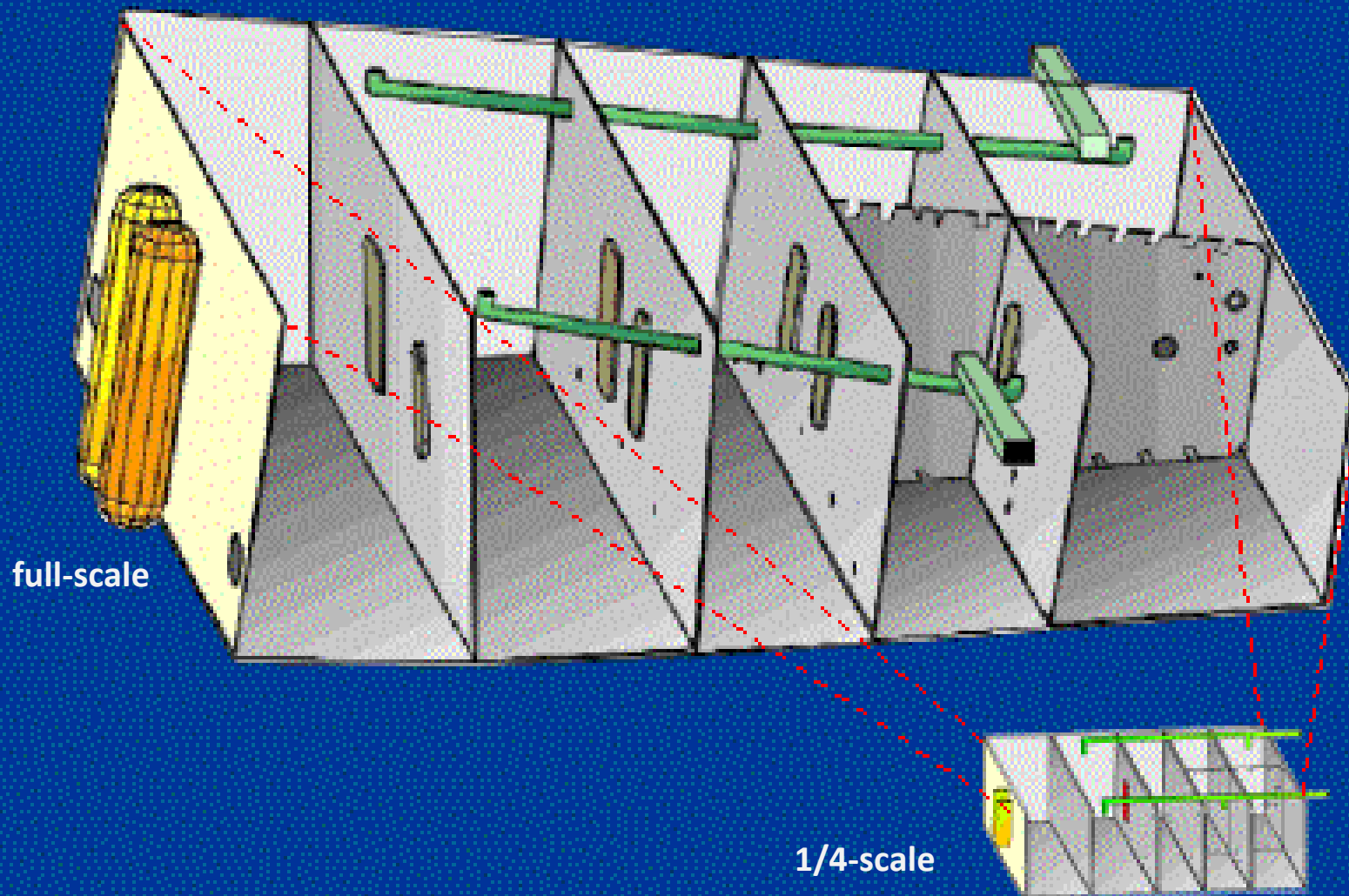
- Jet A vapor
- Duplication of TWA 800's
temperature
altitude

**Simulate Combustion Behavior Within a
Center Wing Tank Model**



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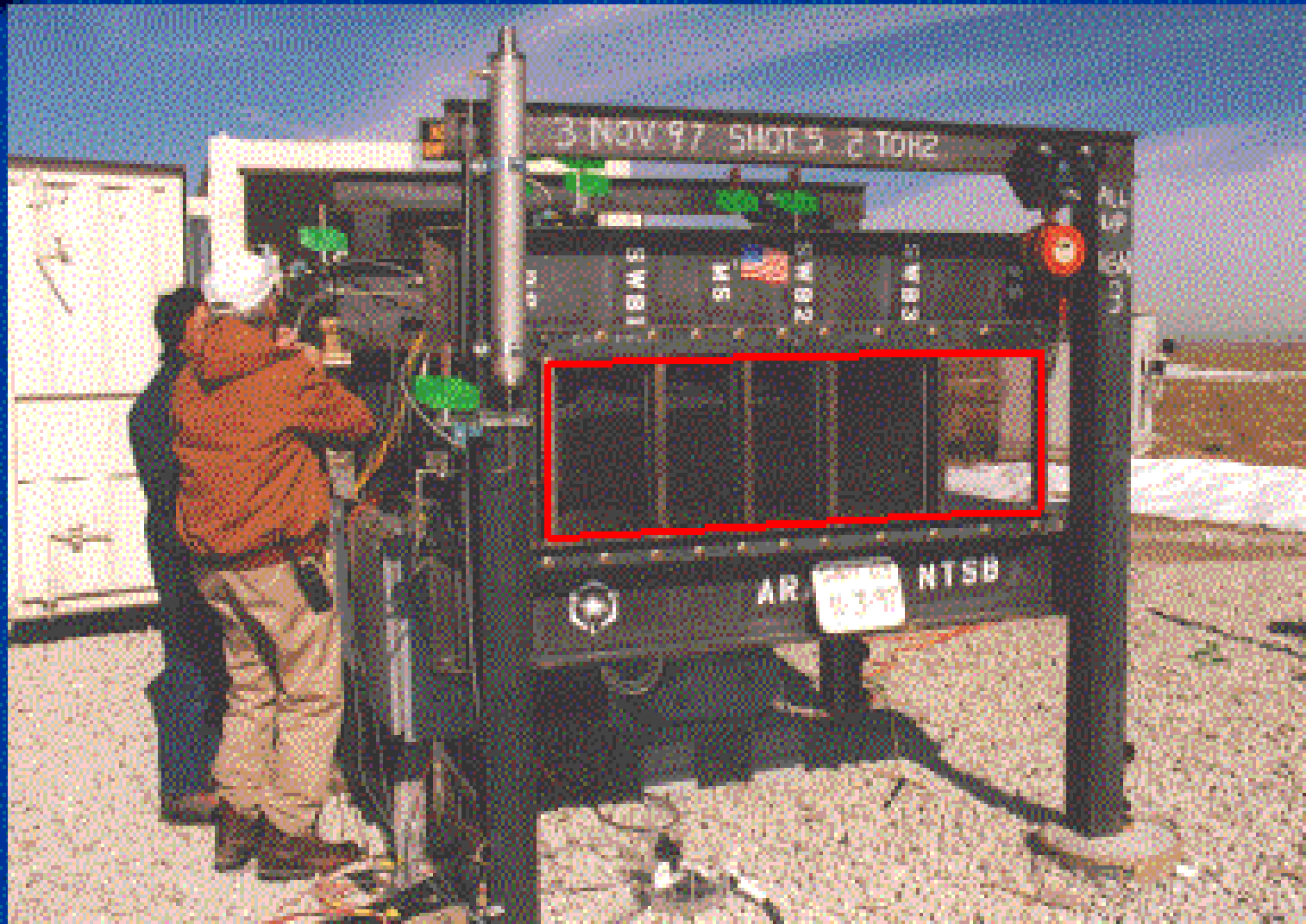
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1/4-scale Center Wing Tank Model



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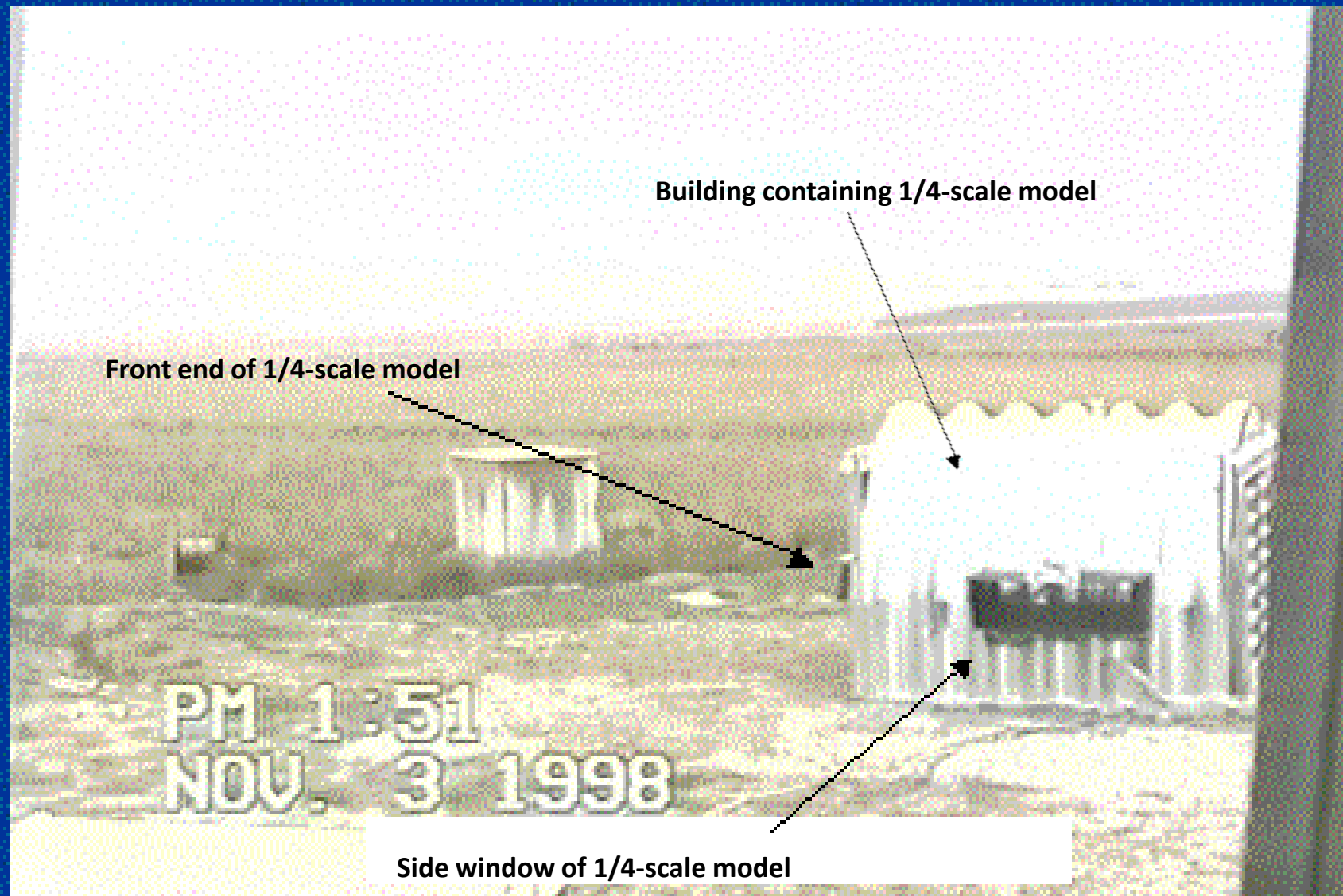


1/4 –scale Center Wing Tank Model Enclosure,
Phases 2 and 3



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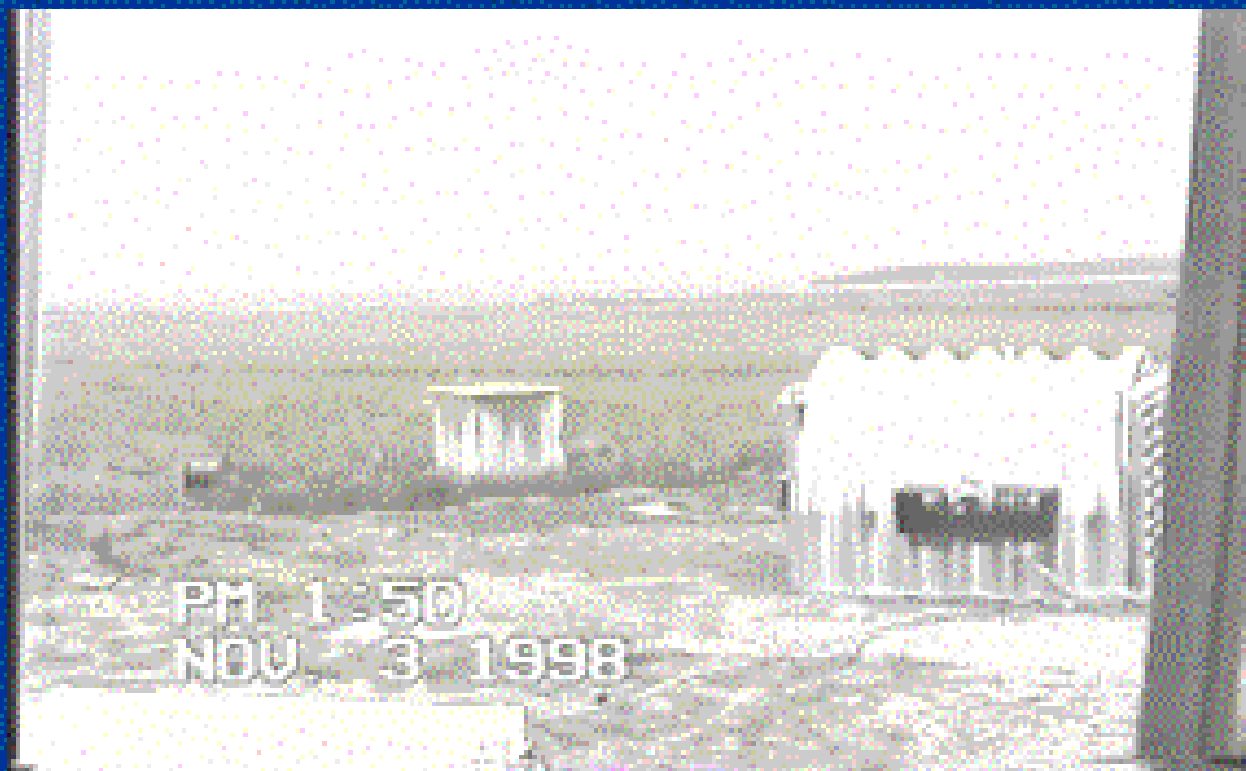
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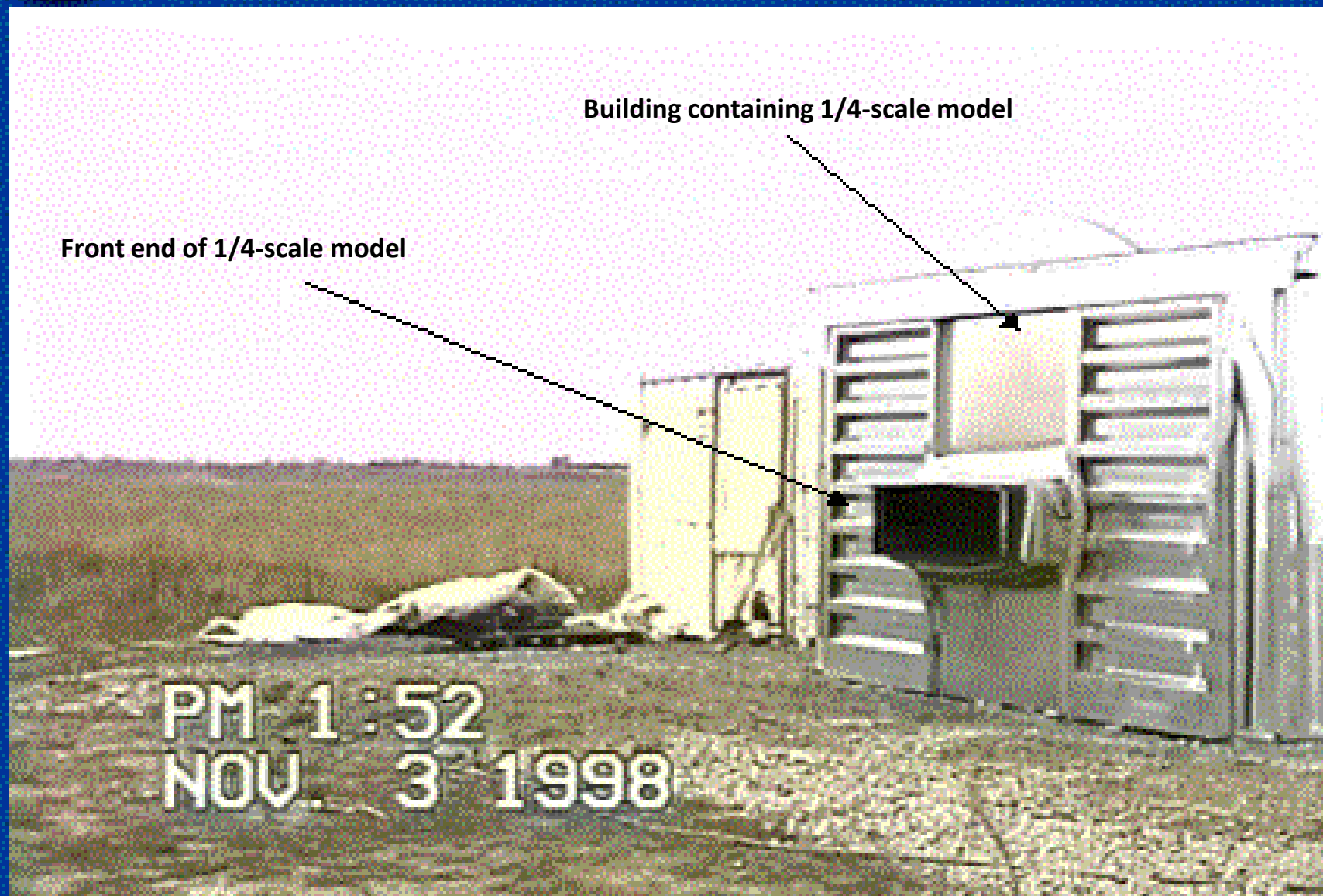


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Building containing 1/4-scale model

Front end of 1/4-scale model



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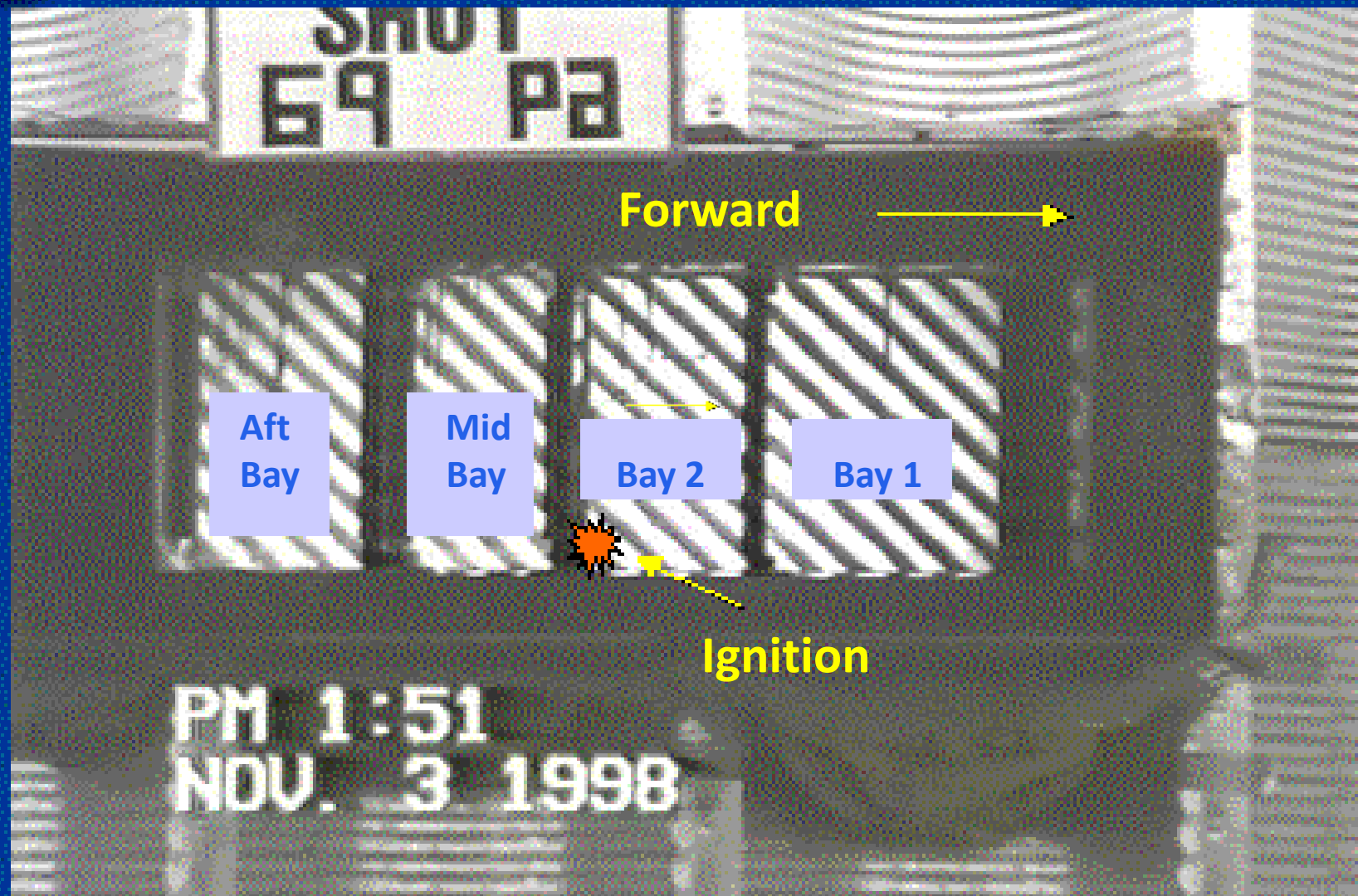
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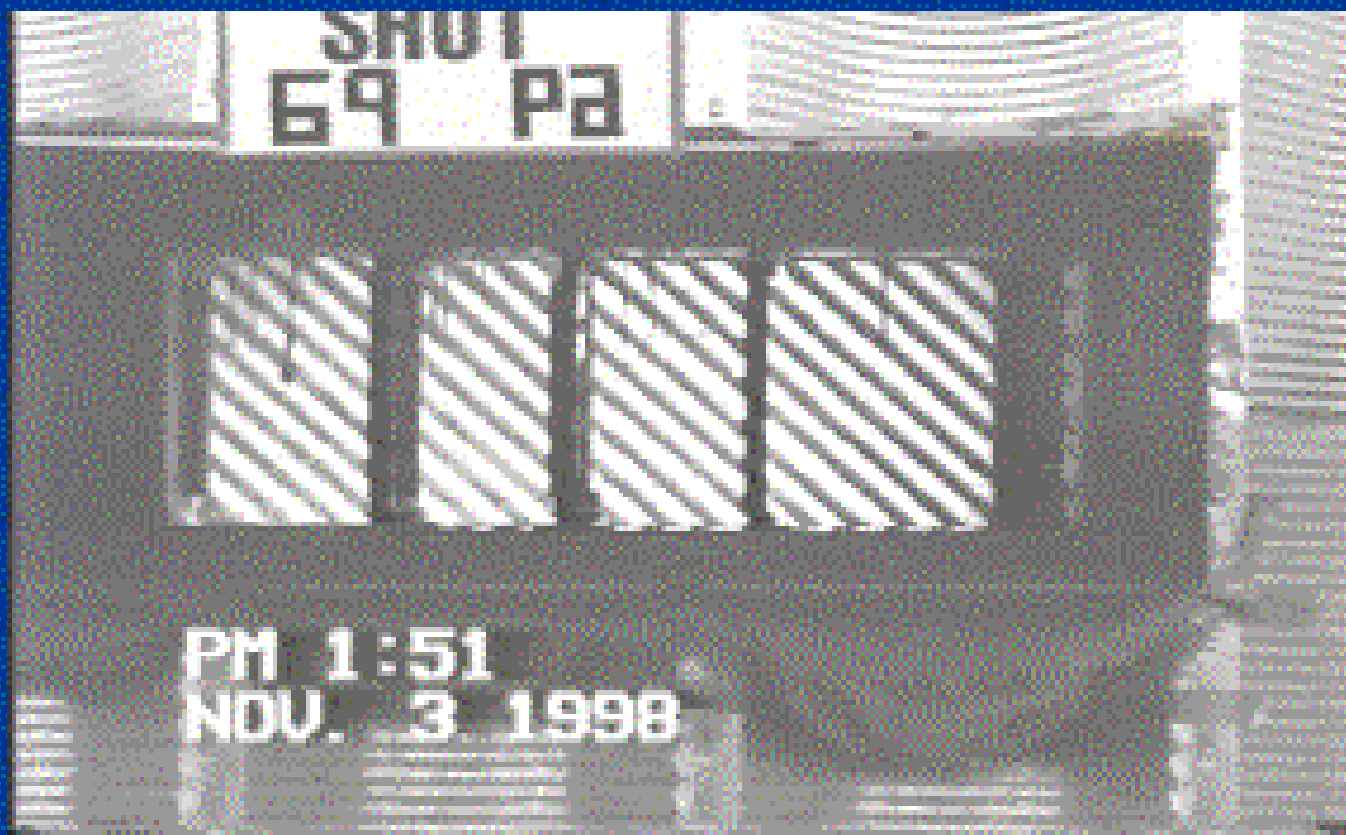
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Findings

1/4-scale experiments show that for the conditions on board TWA 800 at the time of the accident:

- In every test, Jet A fuel vapor was demonstrated to be flammable
- Peak pressures can develop that exceed the structural limitations of the center wing tank



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Findings

- **The condition inside the center wing tank was flammable.**

Verified by: Flight test measurements

In-flight vapor sample analysis

Laboratory chemical analysis

Laboratory combustion experiments

- **The ignition and combustion of Jet A fuel can generate sufficient pressures to break apart the center wing tank.**

Verified by: Laboratory combustion experiments

1/4-scale model experiments



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1997 to 2000

Christian
Michelsen
Research

Sandia
National
Laboratories

Computer Modeling

- two models developed
- validated with 1/4-scale experiments
- 1/4-scale and full-scale CWT simulations

Calculate the Dynamics of
Full-scale Center Wing Tank Combustion



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1997 to 2000

**Combustion
Dynamics, Ltd**

- **Analyze each computer model simulation scenario and compare to physical evidence**

**Analysis Method to Determine
Probable Ignition Location**



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Findings

Analysis of full-scale computer simulations show:

- Confirmation that peak pressures can be generated that exceed the structural limitations of the center wing tank
- Internal ignition and combustion of Jet A vapor is consistent with the damages observed in the wreckage and with structural failure calculations



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Conclusions

- The condition inside the center wing tank was flammable
- The ignition and combustion of Jet A fuel can generate sufficient pressures to break apart the center wing tank



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